

Dog predation by jaguars in a tourist town on the Mexican Caribbean

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Abstract

Invasion of humans and dogs into the jaguars' habitat opens the way for future negative events. Dog predation by jaguars has only been recorded anecdotally, despite the high risk of pathogen transmission and the potential conflict due to pet predation. In this study, we document jaguar attacks on dogs in Mahahual, Quintana Roo, Mexico, a tourist town in the Mexican Caribbean. In addition, we describe an initiative designed to prevent jaguar persecution by constructing night houses for dogs at the most recent attack sites. A total of 20 attacks were recorded in the last nine years, most of them fatal (60%) on medium-sized dogs (70%), at night (95%) and during the dry season (65%). Half of the attacks occurred in the north of Mahahual's coastline and the other half in the south. Attacks in the south were concentrated between 0 to 10 km away from the village, while in the north they were dispersed over distances between 0 and > 30 km. Thirty-eight night houses were constructed covering almost 45 km of the 135 km of Mahahual's coastline. Further research is required to understand the importance of dogs in the jaguar diet and the impact of dog predation on the health and disease ecology of jaguar populations.

Keywords

Canis lupus familiaris, human-wildlife conflict, Mahahual, *Panthera onca*, potential disease transmission, predation, predator-prey relationship

Introduction

The jaguar (*Panthera onca*) is the largest felid native to the Americas. It ranges from the United States to Argentina and is currently considered as Near Threatened by the International Union for Conservation of Nature (Quigley et al. 2017). Jaguar populations are continuing to decline due to factors such as habitat loss and fragmentation, illegal hunting and poaching of its prey (Caso et al. 2008). Jaguars are carnivorous, opportunistic predators and their diet consists of the available prey in the environment (Hayward et al. 2016). Approximately 85 species have been enlisted as jaguar prey (Seymour 1989), with a preference for medium and small-sized species (e.g., *Cuniculus paca*, *Dasyprocta punctata*, *Dasypus novemcinctus*, *Mazama americana*, and *Tayassu pecari*) (de Oliveira 2002). Depending on the size and weight of their prey, jaguars kill by biting the skull or the neck (dorsal, ventral or lateral) damaging the central nervous system or suffocating the individual (Schaller and Vasconcelos 1978; Crawshaw and Quigley 2002; Pérez-Flores 2018; Pérez-Flores et al. 2020).

It has been documented that jaguars attack species typically uncommon in their diet (e.g., sea turtles and crocodiles) as a consequence of the decline in the populations of their main prey species (Arroyo-Arce and Salom-Pérez 2015; Pérez-Flores 2018). Predation on domestic animals by large felids is a strategy to survive when density and biomass of wild prey are low (Khorozyan et al. 2015), and in human-dominated landscapes where the biomass of domestic prey is higher than wild prey (Kumbhojkar et al. 2020). Domestic animals such as cattle, sheep or goats are easier to prey upon due to their lack of anti-predatory behavior (Diamond 2002). Predation or attacks by jaguars on other domestic species such as dogs have been recorded anecdotally in some countries of Central and South America (Soto-Shoender and Giuliano 2011; Amador-Alcalá et al. 2013; Butler et al. 2014; Fiorello et al. 2017; Jędrzejewski et al. 2017; Hoogesteijn et al. 2020). Only Foster et al (2010) found traces of dogs in jaguar scats from Belize. This suggests that the problem has not been widely studied or that dogs are not of dietary importance for the jaguar, as in the case of the leopard (*Panthera pardus*) where dogs comprise 39–64% of its diet in India (Edgaonkar and Chellam 2002; Athreya et al. 2014).

In countries where jaguars are currently distributed (excluding the United States) there are approximately 113.34 million dogs, with 30% living in rural areas (Gompper 2014). In Mexico, the dog population has been estimated at 26.5 million, with 8 million living in rural areas (villages with < 2500 inhabitants) (INEGI 2010; Gompper 2014). There are different types of rural communities in southern Mexico. Some are tourist communities where people of different nationalities live and where dogs receive little veterinary care (occasional sterilization and vaccination

campaigns), while, in other communities, people live with a high level of poverty and dogs do not receive primary health care (Pérez-Flores pers. obs.). Most dogs in rural communities are free to roam or are tied up near houses, and sometimes are abandoned (Ortega-Pacheco et al. 2007). Dogs in rural communities often face high mortality rates, a short lifespan (2 years), malnourishment, abuse and diseases (Jackman and Rowan 2007).

Dogs are now part of a wide variety of ecosystems and are having a great impact on biodiversity and native wildlife populations through predation, competition for resources, hybridization and diseases transmission to other animals and humans (Jackman and Rowan 2007; Young et al. 2011; Silva-Rodríguez and Sieving 2012; Gompper 2014). Dogs and wild mammals share approximately 168 pathogens, of which 71.4% are viruses, 56.1% helminths, 50% protozoa, 46.7% bacteria, and 15.4% fungi (Cleaveland et al. 2001; Knobel et al. 2014). Some infectious diseases of domestic dogs have had devastating effects on wild felids populations. For instance, the canine distemper virus (CDV) outbreak in lions (*Panthera leo*) which affected 20–30% of the population (3000 individuals) in Tanzania between 1994 and 1995 (Roelke-Parker et al. 1996). Antibodies to CDV, canine parvovirus and rabies virus have been detected in jaguars from Brazil. However, the impact of these diseases on the population dynamics of free-living jaguars remains unknown (Nava et al. 2008; Furtado et al. 2013; Onuma et al. 2016).

In recent years, there has been an increasing concern about jaguar sightings and attacks on dogs in Mahahual, a coastal village in Southern Quintana Roo, Mexico (Carral-García and Rosales pers. obs.). This situation has not been well documented by researchers throughout the jaguar's range. However, attacks and predation of domestic dogs could lead to human-jaguar conflict. The strong attachment of humans to their pets may cause an animal to be killed in retaliation for these events, which is of particular concern in an endangered species such as the jaguar. In addition, there is a possibility that a wide range of pathogens could be transmitted from dogs to jaguars, threatening the health of jaguar population in Mahahual. Thus, attack and predation of domestic dogs by jaguars is deserving of further attention in literature. The objectives of this study were therefore to: 1) record cases of jaguar attacks and predation on dogs in Mahahual; 2) characterize each attack, and 3) find records of dogs preyed upon by jaguars throughout the jaguar's range.

Methods

Study area

Mahahual is located in the municipality of Othón P. Blanco, in the southern part of the state of Quintana Roo, Mexico (18°42'50"N, 87°42'34"W) (Fig. 1). The climate is tropical sub-humid (Aw) with a rainy season from June to November. The annual average precipitation is 1200 mm and the annual average temperature is 26 °C (Sánchez-Sánchez and Islebe 2002). The predominant vegetation type is medium

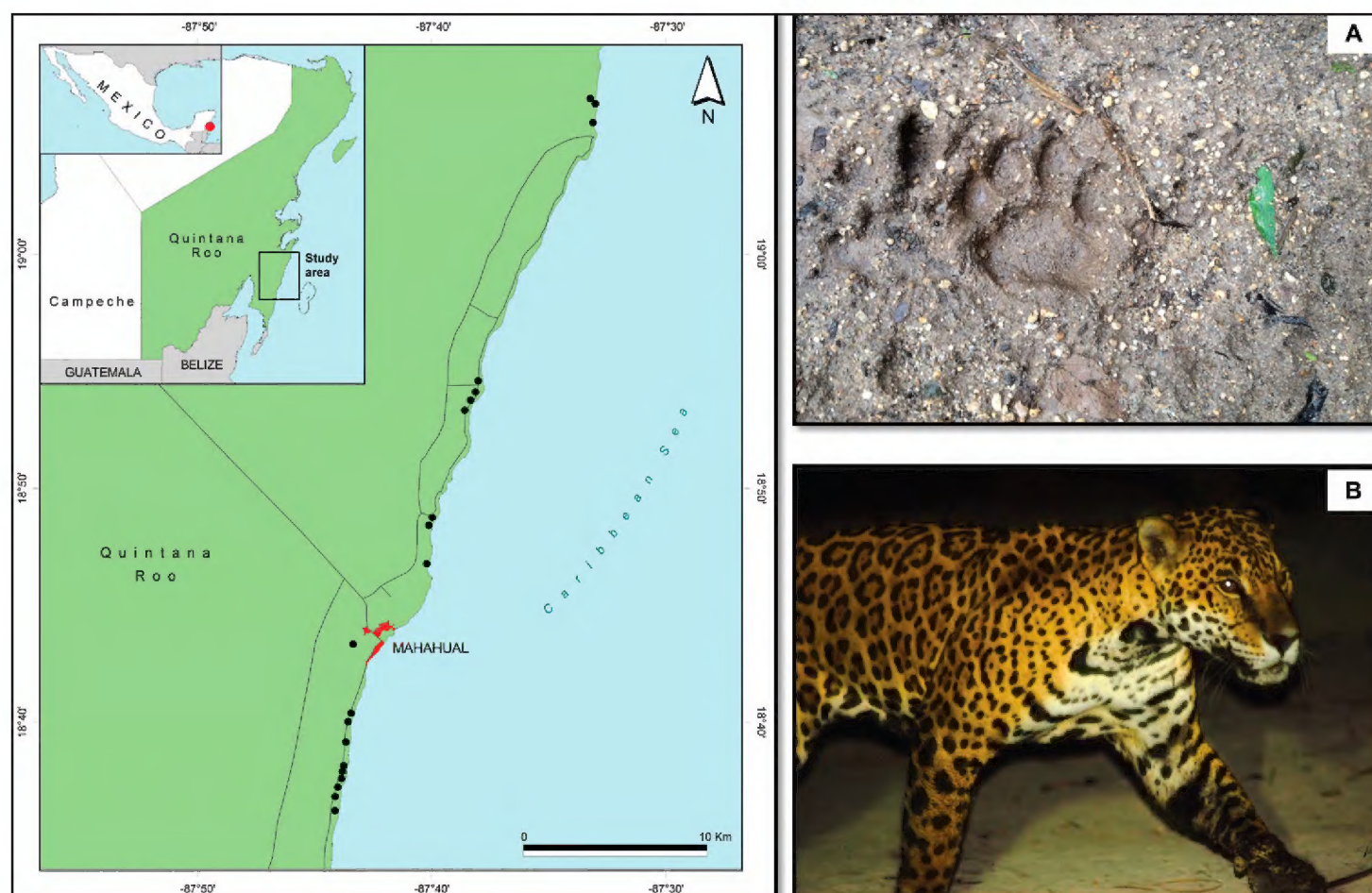


Figure 1. Location of jaguar attacks throughout the coastal area of Mahahual, Quintana Roo, Mexico. Fresh jaguar tracks at one of the predation sites (A), and photographic record of a jaguar in the north of Mahahual (B).

semi-evergreen forest in different successional stages, mangrove and secondary vegetation (Sánchez-Sánchez and Islebe 2002). Mahahual encompasses 980 km² and in five years (2005 to 2010) its population increased from 282 to 920 inhabitants, largely immigrants from Mexico and internationally (INEGI 2015). The principal economic activities are fishing, farming and tourism (Cinner 2000). After the impact of hurricane Dean in 2007, the social structure and landscape of Mahahual changed (Islebe et al. 2009). However, three years later, tourism returned in large numbers (Sosa-Ferreira and Martínez 2016). Currently, due to the demand for tourism (39 ecotourism centers) and the increase in human population, people have begun to live further away from the town where the degree of human disturbance remains low. However, people are typically accompanied by dogs and other domestic animals, which lack appropriate veterinary care. In addition, there is a large number of free-ranging dogs that feed on garbage and roam into the forest, which could result in predation by jaguars and the potential spread of infection if these dogs are carriers of disease (Pérez-Flores pers. obs.) (Fig. 2A–D).

Dog predation in Mahahual

We started recording cases of dogs attacked and preyed by jaguars in 2012, after noticing attacks had become more common in Mahahual and people began to per-



Figure 2. Dogs under different situations in Mahahual, Quintana Roo, Mexico. Dog tied near the house without a backyard fence (A), unhealthy free-roaming dog (B), dog feeding from trash bags in the street (C) and dogs allowed to reproduce (D).

secute jaguars in retaliation to these events of pet predation (Rosales pers. obs.). The corresponding data table below includes the date, dog size (small 0–15 kg, medium 16–30 kg and large >30 kg), the anatomical region where it was injured and the characteristics of the wounds (all animals were clinically evaluated by Carral-García), its fate (missing, killed or alive) and the georeferenced site of the attack using a global positioning system (GPS) device (Garmin ETREX 20).

Jaguars attack on dogs throughout their geographical range

A review of the existing literature on jaguar attacks and predation on dogs was carried out in six search engines: Google Scholar, Red de Revistas Científicas de América Latina y el Caribe, España y Portugal (Redalyc project), Science Direct, Science Electronic Library Online (SciELO), Scopus and Web of Knowledge in English, Portuguese and Spanish. The keywords used were: jaguar, *Panthera onca*, dog, cão, perro, *Canis familiaris*, attack, ataque, predation, predação, depredación, predator-prey, predador-presa and depredador-presa. Additionally, we searched for pictures, videos or reports on social networking (Facebook and Youtube) using the same keywords.

Results

Cases in Mahahual

Twenty cases of dog attacks by jaguars were recorded in the last nine years in Mahahual; 70% of the dogs were male and 30% female. Jaguars attacked medium-sized dogs (70%) and large dogs (30%). The anatomical region where jaguars most often bit dogs was the neck (40%). Sixty percent of the attacks were fatal (dogs disappeared, died at the site of attack or later) and 40% survived (Fig. 3A–F). Almost all attacks were during the night (95%). Most of the attacks were during the dry season (65%) from December to May and the rest (35%) in the rainy season (June to November) (Table 1). Half of the attacks occurred in the north of Mahahual and the other half in the south. Thirty percent of the attacks in the north occurred at a distance between 0 and 10 km from the main city center, 40% between 11 and 20 km, and the rest (30%) at a distance > 30 km. In the south, all the attacks occurred at a distance between 0 and 10 km from the main city center (Fig. 4A, B).

Records of attacks and predation

We found seven scientific publications of jaguars' attacks or predation on dogs. However, 86% of the studies had no evidence of attacks as they were carried out by interviewing local people (Soto-Shoender and Giuliano 2011; Amador-Alcalá et al. 2013; Butler et al. 2014; Fiorello et al. 2017; Jędrzejewski et al. 2017; Hoogesteijn



Figure 3. Different dogs injured as a result of jaguar attacks. Large-sized dog with an open wound of approximately 5 cm (A), multiple open wounds in the neck and near the scapula of a large-sized dog (B), fatal skull bite in a medium-sized dog (C), fatal wound in the thorax of a medium-sized dog (D), large-sized dog with an open wound of 15 cm (E), and multiple open wounds of a medium-sized dog (F).

Table 1. Summary of attacks of jaguars on dogs in Mahahual, Quintana Roo, Mexico, from 2012 to 2019. M = male, F = female, D = disappeared, K = killed, and L = live.

Date	Sex	Size	Injuries	Fate	Time
December 2012	F	Medium	–	D	Night
October 2013	F	Large	–	D	Night
July 2014	M	Medium	Neck	K	Night
October 2014	M	Medium	–	D	Night
October 2014	M	Medium	Superficial injuries	L	Night
January 2015	M	Large	Neck	L	Night
February 2016	M	Medium	–	D	Night
August 2016	M	Medium	–	D	Night
October 2016	M	Large	–	D	Night
February 2017	F	Large	Neck and Skull	K	Night
February 2017	F	Medium	Forelimb	L	Night
September 2017	M	Medium	–	D	Night
January 2018	F	Medium	Neck	K	Night
February 2018	M	Large	Neck and thorax	L	Night
February 2018	M	Medium	Neck	L	Night
February 2018	F	Medium	Thorax	L	Night
February 2018	M	Medium	Neck	L	Day
March 2018	M	Medium	Neck	L	Night
April 2018	M	Medium	–	D	Night
April 2019	M	Large	–	D	Night



Figure 4. Jaguars wandering around the houses recorded using camera traps from different sites of Mahahual, Quintana Roo, Mexico. Jaguar recorded 18 km north from the center of Mahahual (A), and jaguar recorded 10 km south from the center of Mahahual (B).

et al. 2020). Only one study found dog remains in jaguar feces, it is not known whether it was predated or scavenged (Foster et al. 2010). We found eight reports on local news and social media referencing predation of jaguars on dogs between 2015 and 2019. Five were documented in Mexico, two in Brazil and one in Guatemala. Most of the attacks occurred in urban areas (50%) and secondly in rural areas (25%). Jaguars prefer to attack at night (50%) rather than during the day (37.5%). The anatomical region where dogs are most frequently bitten is the neck 73% (Fig. 5A, B; Table 2).

Table 2. Summary of attacks of jaguars on dogs in North, Central and South America from different sources. NPA = natural protected area, R = rural, U = urban, and Z = zoo.

Country	Year	Time	Zone	Injuries	Source
Guatemala	2016	—	U	—	Local news
Brazil	2015	Night	U	Neck	Youtube
Brazil	2016	Day	R	Neck	Local news
Mexico	2016	Night	U	Neck	Youtube
Mexico	2018	Day	NPA	Neck	Facebook
Mexico	2018	Night	R	Thorax	Local news
Mexico	2018	Night	U	Muscles, tendons and bones	Local news
Mexico	2019	Day	Z	Face	Local news



Figure 5. Dog attacked by a jaguar in the Pantanal, Brazil. Jaguar and free-roaming dogs are in close contact in rural areas (A) and jaguar biting the neck of a dog to suffocate and drag it away (B).

Discussion

Our study aimed not only to record the number of jaguar attacks on domestic dogs in Mahahual, Mexico, but also to bring attention to a subject of concern that could be replicated in further studies in different regions of Central and South America. Humans and dogs continue to encroach on jaguar habitat; our results showed that jaguars attack and kills dogs where people and their pets are most concentrated. Dogs appear to be an accessible prey, especially at night and during the dry season.

With human and domestic dog populations increasing throughout Central and South America and encroaching on jaguar habitat (Gompper 2014), we are increasing the likelihood for human-wildlife conflict. There are an estimated 34 million dogs in rural areas of countries within the jaguar’s range (Gompper 2014). In southern Mexico, many rural areas have no access to veterinary services, leading to dog overpopulation and diseases (Ortega-Pacheco et al. 2007). In Mahahual, sterilization and vaccination campaigns are conducted every six months, but residents continue bringing dogs into the town from different sites of the Yucatan Peninsula (Carral-García pers. obs.). Most attacks in Mahahual were on males, probably because there is a higher population of male dogs. This may be related to the belief that males are better guard dogs and to avoid the possibility of a female becoming pregnant (Jackman and Rowan 2007).

The number of attacks was similar in both north and south. However, attacks were concentrated particularly within the first 10 km due to a higher concentration of infrastructure (houses, hotels, roads) and people, including their own pets. In the north, on the other hand, people and their pets are more dispersed, and not much infrastructure has been built. Residents owning small dogs (< 15 kg) usually keep them indoors; while medium and large-sized dogs roam free or are tied up near houses. We assumed that this is the main reason why we only recorded jaguars' attacks on medium and large sized dogs, in addition to the fact that these are considered preferred prey size for jaguars (de Oliveira 2002).

The behavioural plasticity of big cats has led them to adapt to use human-dominated landscapes and to prey on a wide variety of domestic animals (Athreya et al. 2014). In India, leopards have adapted to kill and eat dogs because they are abundant in rural and suburban areas (Athreya et al. 2014). This could be happening with jaguars in Mahahual, as we observed several similarities in the way jaguars and leopards attacked dogs. First, most attacks were during the night (Butler and Bingham 2000) when there is less surveillance by owners. Second, both kill dogs in backyards or near houses (Butler and Bingham 2000). This behaviour has also been documented in pumas (*Puma concolor*) from two Canadian provinces and in 15 US states, where there are no jaguars, and pumas are larger (Gompper 2014). Third, there is a seasonality in dog predation, with both killing more dogs during the dry season than in the rainy season (Butler and Bingham 2000). Probably in Mahahual as in other sites of the Yucatan Peninsula, jaguars limit their movements during the dry season (González-Gallina et al. 2017) and take advantage of the vulnerability of domestic animals. Additionally, during droughts, the availability of jaguars' natural prey decreases, as hunters exert heavier hunting pressure over these species due to the accessibility of hunting sites (Santos-Fita et al. 2012).

Although we do not know why a high percentage of dogs survived, some of the owners mentioned that when they heard the dogs crying, they immediately turned on the lights and made noise to scare the jaguar. The surviving dogs received clinical veterinary assistance, but some of them died a few hours later as a consequence of skull fractures, damage to the internal jugular vein and septicaemia (Carral-García pers. obs.). Jaguars and leopards usually attack from a blindside, biting the dogs on the neck (dorsal, ventral, lateral) or in the skull, to avoid counterattacks and then drag them away.

To date, the construction of night houses has been perceived by local people as an effective strategy to reduce attacks (Fig. 6A–D). However, some houses have been found bitten and with jaguar tracks around them, suggesting that jaguars have tried to take the dogs out (Rosales pers. obs.). Jaguars continue attacking in areas where houses do not have fenced backyards and dogs roam free. The effectiveness and feasibility of this strategy needs to be analysed and monitored over the long term, as so far only 30% (45 km) of Mahahual's coastline has been covered and people continue to arrive and bring pets, as well as building new infrastructure and roads.



Figure 6. Night houses built by the local community in Mahahual, Quintana Roo, Mexico, in association with Aak Mahahual A.C. Construction of different size of night houses (A), people keeping their dogs (B), small night house with capacity for two dogs (C) and dogs safe in the night house (D).

The lack of scientific and local interest in dog predation by jaguars is striking, suggesting that these events go unreported or occur in areas where they are common and are not newsworthy. We may be underestimating the number of attacks because many dogs roam freely and have no owners, so their disappearance goes unnoticed. In the Pantanal, Brazil, 30 dogs were killed by jaguars in three years (Martin pers. com.), and in the villages of the Calakmul region, Campeche, Mexico, we have recorded several jaguar attacks on free roaming dogs in the last five years (Pérez-Flores pers. obs.). Recently, Hoogesteijn et al (2020) reported a jaguar persistently preying on dogs in Playa del Carmen, Quintana Roo, Mexico. It was captured and translocated to another location away from human settlements. However, it approached four villages (in a radius of 6 km) and returned to preying on dogs. The persistent dog-eating behaviour of jaguars has led to an increase in negative events between humans and jaguars, due to the high affection for companion and hunting dogs by people living in these areas. Unfortunately, some jaguars have been persecuted and killed (Pérez-Flores and Rosales pers. obs.), threatening the long-term viability of its populations.

Conclusions

This study allowed us to document a large number of cases of jaguar attacks on dogs in one of the most important tourist sites in Quintana Roo, Mexico. Although we do not know the importance of dogs in the jaguar's diet, we hypothesized that dog consumption is related to the decrease in natural prey and because they are easy to prey. If humans and domestic animals continue encroaching in the jaguar's habitat, disease transmission and human-jaguar conflict will likely increase, potentially resulting in population declines. Further research is required to comprehend the adaptability and persistence of jaguars in human-dominated landscapes and the ecological impact of dog predation by jaguars. Additionally, future studies should focus on evaluating the efficacy of the night houses to understand whether this strategy reduces the amount of dog attacks by jaguars.

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